



GEOTECHNICAL ENGINEERING REPORT
FOR
CITY OF COLUMBIA

MORES LAKE DAM GLOBAL
STABILITY ANALYSES
COLUMBIA, MISSOURI

JULY 25, 2014

Crockett GTL Project Number: G13043

500 Big Bear Blvd. • Columbia, MO 65202

Phone: 573-447-3981

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500 Big Bear Boulevard
Columbia, Missouri 65202
(573) 447-3981

July 25, 2014

City of Columbia – Power Plant
P.O. Box 6015
Columbia, MO 65205

Attn: Mr. Christian Johanningmeier, P.E.

Re: Geotechnical Engineering Report
Mores Lake Dam Global Stability Analyses
Columbia, Missouri
Crockett GTL Project Number: G13043

Dear Mr. Johanningmeier:

Crockett Geotechnical – Testing Lab (Crockett GTL) has completed the geotechnical engineering services for the referenced project. This report should be read in its entirety. Our services were performed in general accordance with our proposals dated November 20, 2013 and April 3, 2014. This report presents the results of our field explorations, laboratory testing, and findings regarding the stability of the dam slopes.

We appreciate the opportunity to work with you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

A handwritten signature in blue ink that reads "Shane Steinman".

Shane Steinman, E.I.
Project Manager

Eric H. Lidholm, P.E.
Principal Engineer
Missouri: E-23265



Enclosures

cc: 1 – Client (.PDF)
1 – File

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**Geotechnical Engineering Report
More Lake Dam Global Stability Analyses
Columbia, Missouri
Crockett GTL Project Number: G13043
July 25, 2014**

1 INTRODUCTION

Crockett Geotechnical - Testing Lab (CGTL) has conducted a geotechnical exploration for Mores Lake Dam slope stability analyses. The purpose of our exploration was to:

- characterize and evaluate the subsurface conditions,
- perform global stability analyses for three sections of the dam

Our services were performed in general accordance with our proposals dated November 20, 2013 and April 3, 2014.

2 SITE AND PROJECT INFORMATION

2.1 SITE LOCATION

Item	Description
Location	This project is located approximately 600 feet north of the intersection of Lakeview Avenue and Edison Street in the City of Columbia, MO.
Approximate GPS Coordinates	Latitude: 38.966587° Longitude: -92.317311 °

2.2 PROJECT DESCRIPTION

A report entitled "Assessment of Dam Safety of Coal Combustion Surface Impoundments – Draft Report" dated October 2012 and revised in July 2013 was prepared by CDM Smith, Inc. In this draft report, in section 7.1.4 (page 7-2), it stated CDM Smith, Inc. could not review the adequacy of the factors of safety for a number of conditions. The conditions requiring analyses are presented in the following table.

USACE Recommended Minimum Factors of Safety		
Analysis Condition	Required Minimum Factor of Safety	Slope
End of Construction		
• Including staged construction	1.3	Upstream and Downstream
Long Term		
• steady state seepage, maximum storage pool, spillway crest or top of gates	1.5	Downstream
Maximum Surge Pool	1.4	Downstream
Rapid Drawdown		
• Maximum Surge Pool	1.1	Upstream
• Maximum Storage Pool	1.3	Upstream
Seismic Conditions at Normal Pool Elev.	1.0	--
Liquefaction	1.3	Not Applicable

Crockett GTL was retained by the City of Columbia to perform these analyses. In order to determine areas of the dam that warranted analysis, Crockett GTL obtained historical maps and drawings regarding Mores Lake Dam. After reviewing these documents, it was determined three sections of the dam should be evaluated. The areas that were investigated were on the west side of the dam (borings B-1 and B-2), the northwestern side (borings, B-3, B-4, and B-7 through B-10) of the dam. These areas were chosen due to a historical topographic map (1935 Columbia, MO quadrangle – see adjacent) indicated possible wet-weather drainage swales could exist prior to the construction of the dam. The third area investigated (borings B-5 and B-6) was on the northern portion of the dam and was chosen as a typical “non-swale” location. A boring location diagram included in the Appendix of this report shows the specific boring locations.



3 SUBSURFACE CONDITIONS

3.1 FIELD EXPLORATION AND LABORATORY TESTING

Ten (10) borings were drilled for this project at the approximate locations indicated on the Boring Location Plan included in the Appendix of this report. The boring locations were designated by a CGTL geotechnical engineer. Approximate boring elevations were obtained from a topographic site plan prepared by Engineering Surveys and Services. The boring locations and elevations should be considered accurate only to the degree implied by the means and methods used to define them.

Borings were drilled with a truck mounted drill rig. Representative samples were obtained using thin-walled tube and split-barrel tube sampling procedures.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

The field logs were prepared by the drill crew. Final logs included with this report represent the engineer's interpretation of the field logs and include modifications based upon laboratory tests and observation made of the samples. The descriptions of the soil on the final boring logs are in general accordance with the Unified Soil Classification System which is included in the Appendix of this report.

Detailed information regarding the material encountered and the results of field sampling and laboratory testing are shown on the Boring Logs included in the Appendix of this report.

3.2 ENCOUNTERED SUBSURFACE CONDITIONS

Surficial material consisted primarily of topsoil or gravel.

Below the surficial material, with the exception of borings B-9 and B-10, was fill. The fill was variable and consisted of sandy clay, lean to fat clay, fat clay, cobbles and boulders, and cinders. Boring B-8 terminated at 25 feet and appeared to still be encountering uncontrolled fill material.

Underlying the surficial material in borings B-9 and B-10, and the fill in the remaining borings was native soil that was visually identified as glacial drift. The glacial drift, as encountered in the borings, was comprised of a mixture of lean to fat clay, fat clay, clayey sand, some sandy zones.

None of the borings encountered bedrock however split spoon sampler refusal was achieved on apparent dense cobbles and possible boulders within the glacial drift in borings B-3, B-5, and B-9. Borings were extended to depths ranging from 19.6 feet to 60 feet.

Detailed descriptions of the encountered materials are listed on the individual boring logs included in the Appendix of this report. Strata lines indicate the approximate location of changes in material types. The transition between material types may be gradual.

3.3 GROUNDWATER

Groundwater was encountered in all of the borings. Borings B-1 through B-6 were converted into piezometers for long term groundwater analysis. Delayed groundwater readings are provided in the table, below. Borings B-7 through B-10 were backfilled immediately, for safety reasons, and no delayed groundwater readings were taken. Groundwater records are indicated on the boring logs included in the Appendix of this report.

Boring Number	Date Drilled	Groundwater Depth, feet	
		At time of Drilling	On 6-30-14
B-1	1-2-14	16.0	8.8
B-2	1-10-14	9.0	Note 1
B-3	1-3-14	19.0	5.5
B-4	1-9-14	8.0	4.2
B-5	1-8-14	13.0	7.5
B-6	1-9-14	13.5	3.3
B-7	6-30-14	7.0	7.0
B-8	6-30-14	5.0	5.0
B-9	6-30-14	7.0	7.0
B-10	6-30-14	3.5	3.5
1. Could not obtain reading due to a City of Columbia back-hoe being parked on top of piezometer cap.			

Groundwater levels depend on seasonal and climatic variations and may be present at different levels in the future. In addition, without extended periods of observation, accurate groundwater level measurements may not be possible, particularly in low permeability soils.

4 GLOBAL STABILITY ANALYSES

Global stability analyses were performed for three sections of the dam. These analyses were performed using STABL for Windows 3.0 slope stability program. This program utilizes simplified Bishop, Janbu, and Spencer methods of analyses. A search routine is used to evaluate a number of trial failure surfaces so the location of the critical failure surface (i.e. – the failure surface with the lowest factor of safety) can be estimated.

A topographic survey performed by Engineering Surveys and Services and the borings drilled for this geotechnical engineering investigation were used to develop a topographic and geologic cross sections for 3 separate areas of the dam. A summary of the analyses results are presented in the table below.

USACE Recommended Minimum Factors of Safety				
Analysis Condition	Required Minimum Factor of Safety	Calculated Minimum Factor of Safety		
		Section B-1/B-2	Section B-3/B-4 & B-7 – B-10	Section B-5/B-6
End of Construction				
• Including staged construction	1.3	2.3	1.0 ¹	2.3
Long Term				
• steady state seepage, maximum storage pool, spillway crest or top of gates	1.5	2.2	2.7	2.4
Maximum Surcharge Pool	1.4	2.2	2.7	2.4
Rapid Drawdown				
• Maximum Surcharge Pool	1.1	2.3	2.3	1.8
• Maximum Storage Pool	1.3	2.3	2.3	1.8
Seismic Conditions at Normal Pool Elev.	1.0	1.1	1.2	1.4
Liquefaction ¹	1.3	N.L. ²	N.L. ²	N.L. ²
1. Does not meet minimum required factor of safety if new construction. 2. N.L. = Not Liquefiable, $PI > 12$ or $W_c / LL < 0.85$ and/or $N_{60} > 25$				

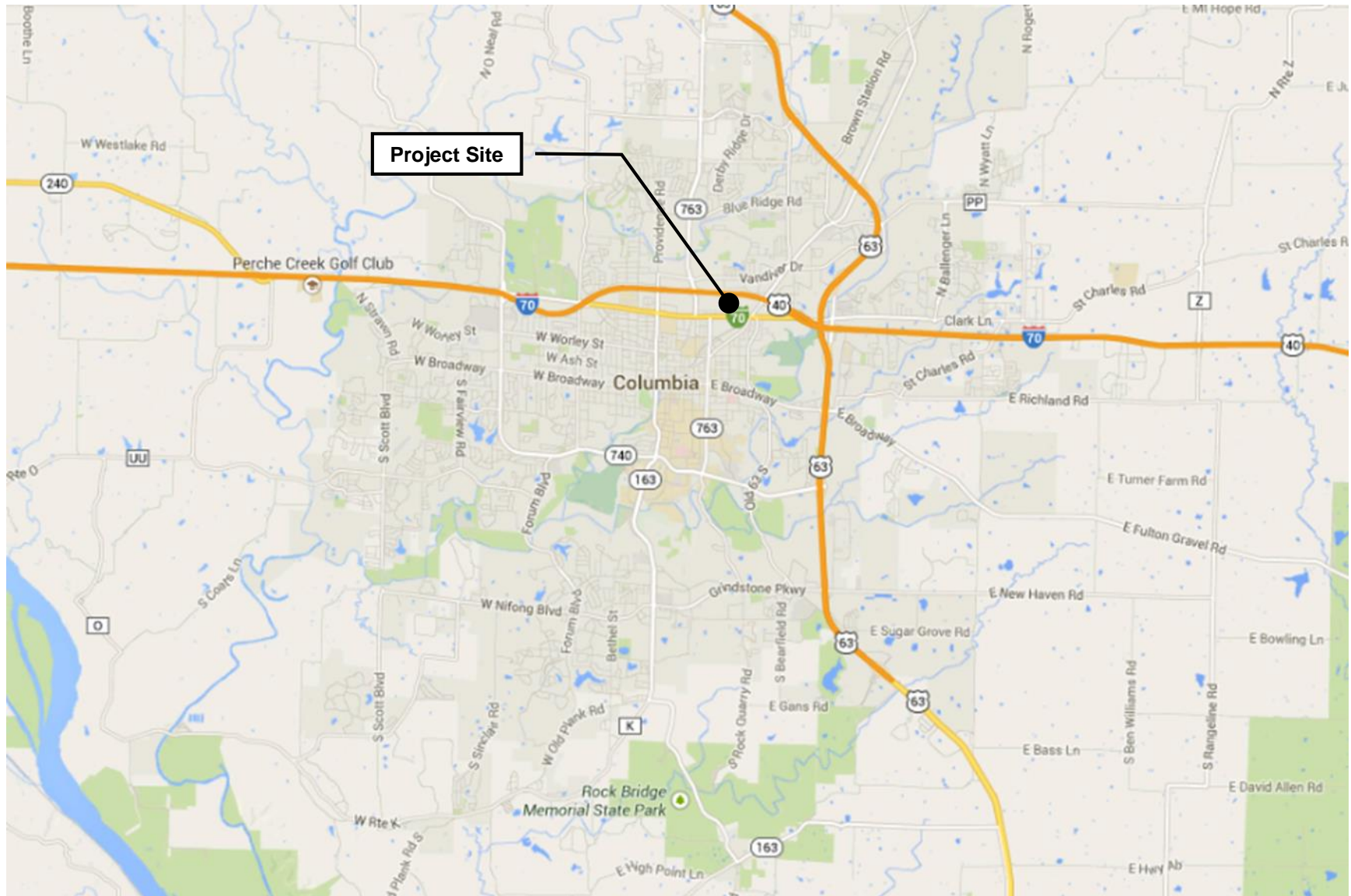
All global stability analyses, with the exception of the end of construction analyses for the northwestern portion of the dam, exceeded the required minimum factors of safety. The soil encountered in the borings was also non-liquefiable resulting in satisfactory liquefaction analyses.

The end of construction analysis for the northwestern section of the dam resulted in a factor of safety slightly higher than 1.0. As this dam is not new construction, but rather over 100 year old construction, this factor of safety is of concern only if additional construction would be performed in this area of the dam. Should additional fill or new construction be required in this area, it is important to engage a geotechnical engineering consultant that can monitor pore water pressures and develop safe construction sequencing to manage and improve this area of the dam.

5 GENERAL COMMENTS

The analyses and recommendations provided herein are for the exclusive use of our client. Our analyses and recommendations are specific only to the project described herein and are not meant to supersede more stringent requirements of local ordinances or codes. The analyses and recommendations are based on subsurface information obtained at our boring locations, sample locations, our understanding of the project as described in this report, and geotechnical engineering practice consistent with the current standard of care. No warranty is expressed or implied. CGTL should be contacted if conditions encountered are not consistent with those described.

APPENDIX



PROJECT NO.: G13043

SITE LOCATION MAP

MORES LAKE DAM
GLOBAL STABILITY ANALYSES
COLUMBIA, MISSOURI

Prepared By:

CROCKETT
GEOTECHNICAL - TESTING LAB

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PROJECT NO.: G13043

BORING LOCATION PLAN

MORES LAKE DAM
GLOBAL STABILITY ANALYSES
COLUMBIA, MISSOURI

Prepared By:

CROCKETT
GEOTECHNICAL - TESTING LAB

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DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
0.1		TOPSOIL (<1")	771.9									
3.0		FILL: Fat Clay, brown, trace gray, trace sand, hard	769.0	SH 1	14	9000		120	15			
5.0		FILL: Lean to Fat Clay, brown, very stiff	767.0	SH 2	19	7000		118	10			
		FILL: Lean Clay, silty, dark brownish gray, stiff		SH 3	20	4000		97	26	36	22	14
10.0			762.0	SH 4	15	3000	4970	104	20			
		▼ FILL: Fat Clay, brown, trace gray, trace sand, soft to stiff		SH 5	12	3500	1540	95	29			
		▽ Torvane = 350 psf		SH 6	17	1500	1540	97	26	50	16	34
20.0		Torvane = 500 psf		SH 7 top	11	1000		97	29			
		--: more sand, dark gray, soft		SH 7 bot	12	1000	890	86	24			
		Torvane = 500 psf										
26.0		Torvane = 200 psf	746.0	SH 8 top	12	8500		95	30			
		LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, very stiff to hard (Glacial Drift)		SH 8 bot								
32.5			739.5	SH 9	10	9000		120	15	33	18	15
		COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)										
35.5			736.5	⊗ SPT 10	14	30-26-32 (58)	7000		14			
		LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)		⊗ SPT 11	12	27-39-50/3"	5000		17			
47.0			725.0	⊗ SPT 12	12	8-17-38 (55)			24			
		CLAYEY SAND: Silty, gray, variable grain size (silt to coarse sand), dense (Glacial Drift)		⊗ SPT 13	18	11-12-28 (40)			18			
				⊗ SPT 14	8	6-14-31 (45)			21			
60.0			712.0	⊗ SPT 15	6	9-12-30 (42)			22			
Bottom of borehole at 60.0 feet.												

CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses
PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri
DATE STARTED 1/10/14 **COMPLETED** 1/10/14 **GROUND ELEVATION** 758 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**
DRILLING METHOD 6" HSA ▽ AT TIME OF DRILLING 9.00 ft / Elev 749.00 ft
LOGGED BY Lidholm **CHECKED BY** Lidholm **AT END OF DRILLING** ---
NOTES Piezometer installed upon completion of drilling **AFTER DRILLING** ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.0		FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	757.0									
3.0		FILL: Fat Clay, brown, trace gray, trace sand, very stiff	755.0	SH 1	16	4500						
		FILL: Lean to Fat Clay, brown, stiff		SH 2	5	3000	3150	105	20			
8.0		▽ LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, medium to very stiff (Glacial Drift)	750.0	SH 3	18	3000	2330	109	19			
				SH 4	22	8000	1630	110	19			
17.0		COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)	741.0									
18.5		LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, stiff to hard (Glacial Drift)	739.5	SPT 5	18	13-21-31 (52)	9000		14			
				SPT 6	16	11-20-35 (55)	3000		16			
27.0		CLAYEY SAND: Silty, gray, variable grain size (silt to coarse sand), very dense (Glacial Drift)	731.0									
30.0			728.0	SPT 7	12	14-26-49 (75)	4500		24			

Bottom of borehole at 30.0 feet.

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
0.1		TOPSOIL (<1")	770.9									
3.0		FILL: Fat Clay, brown, trace gray, trace sand, medium to stiff	768.0	SH 1	12	9000		108	19			
		FILL: Lean to Fat Clay, brown, soft to very stiff		SH 2	11	4000	1610	98	25			
10				SH 3	12	3000	1830	103	22			
				SH 4	13	2000	2670	101	26	51	15	36
		13.0 FILL: Lean Clay, silty, dark brownish gray, stiff	758.0									
				SH 5	18	1500	1620	98	25			
20												
				SH 6	24	5000		97	26	38	15	23
				SH 7	24	1000	1280	101	21			
30												
		32.0 LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, very stiff to hard (Glacial Drift)	739.0	SH 8	24	0	1730	89	33			
				SH 9	19	5000		104	24	44	17	27
40												
		42.0 --: sandy zone	729.0	SH 10	22			97	26			
		45.0 COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)	726.0									
		LEAN TO FAT CLAY: Brown and dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)		SPT 11	8	13-20-26 (46)			21			
50												
		50.6 Refusal at 50.7 feet. Bottom of borehole at 50.7 feet	720.4	SPT 12	6	50-50/1"	4000		23			

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BORING NUMBER B-4

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CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses
PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri
DATE STARTED 1/9/14 **COMPLETED** 1/9/14 **GROUND ELEVATION** 752 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**
DRILLING METHOD 6" HSA **AT TIME OF DRILLING** --- Not Encountered
LOGGED BY Lidholm **CHECKED BY** Lidholm **AT END OF DRILLING** --- Not Encountered
NOTES Piezometer installed upon completion of drilling **2hrs AFTER DRILLING** --- Not Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.5		FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	750.5									
4.5		FILL: Fat Clay, brown, trace gray, trace sand, stiff	747.5	SH 1	17	3000	2300	98	26			
8.0		FILL: Lean to Fat Clay, brown, trace gray, stiff	744.0	SH 2	21	4000	3930	107	21			
10		FILL: Cinders, black, loose		SPT 3	5							44
12.5		FILL: Lean to Fat Clay, brown, trace gray, trace sand, very soft to medium	739.5	SPT 4	1							41
17.0		Torvane = 100 psf	735.0	SPT 5	16	0						28
		LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, very stiff to hard (Glacial Drift)		SPT 6	12	2000						26
20				SPT 7	15	16-26-28 (54)	5000					19
28.0			724.0	SPT 8	10	5-8-10 (18)	9000					25
30.0		LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)	722.0	SPT 9	6	5-14-17 (31)	5500					20

Bottom of borehole at 30.0 feet.

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

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BORING NUMBER B-5

PAGE 1 OF 1

CLIENT <u>City of Columbia</u>	PROJECT NAME <u>Power Plant Dam Stability Analyses</u>
PROJECT NUMBER <u>G13043</u>	PROJECT LOCATION <u>Columbia, Missouri</u>
DATE STARTED <u>1/8/14</u> COMPLETED <u>1/8/14</u>	GROUND ELEVATION <u>771 ft</u> HOLE SIZE <u>6"</u>
DRILLING CONTRACTOR <u>IPES</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>6" HSA</u>	AT TIME OF DRILLING <u>---</u>
LOGGED BY <u>Lidholm</u> CHECKED BY <u>Lidholm</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Piezometer installed upon completion of drilling</u>	AFTER DRILLING <u>---</u>

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\PROJECTS\2013\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
0.1		TOPSOIL (<1")	770.9									
3.0		FILL: Fat Clay and Cinders, brown, trace gray, trace sand, very stiff	768.0	SH 1	19	7000			13			
		FILL: Fat Clay, brown, trace gray, trace sand, medium to stiff		SH 2	99	1500	1370	97	26	47	16	31
10.0		Torvane = 500 psf		SH 3	9	3000		98	24			
		FILL: Lean to Fat Clay, brown, trace gray, trace sand, very soft	761.0	SH 4	24	0	340	94	28	36	15	21
		Torvane = 300 psf										
		Torvane = 200 psf		SH 5	24	0			31			
19.0		752.0										
		LEAN TO FAT CLAY: brown, trace gray, trace sand and fine gravel, stiff to very stiff (Glacial Drift)		SH 6	24	5500	2490	113	13	40	14	26
				SPT 7	12	3-8-11 (19)	5500		19			
29.0		742.0										
		LEAN TO FAT CLAY: Brown and gray to dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)		SH 8	21	7500	4640	119	16			
		--: sandy zone		SPT 9	14	20-46-37 (83)	9000		17			
				SPT 10	15	11-27-27 (54)	9000		18			
43.5		727.5										
		COBBLES AND BOULDERS: Dense to very dense (Glacial Drift)		SPT 11	5	13-26-31 (57)	5500		19			
47.7		723.3										
		Refusal at 47.7 feet. Bottom of borehole at 47.7 feet.		SPT 12	2	50/3"			8			

CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses
PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri
DATE STARTED 1/9/14 **COMPLETED** 1/9/14 **GROUND ELEVATION** 755 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**
DRILLING METHOD 6" HSA **AT TIME OF DRILLING** ---
LOGGED BY Lidholm **CHECKED BY** Lidholm **AT END OF DRILLING** ---
NOTES Piezometer installed upon completion of drilling **AFTER DRILLING** ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.5		FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate										
4.0		FILL: Fat Clay, brown, trace gray, trace sand, hard	SH 1	12		3000		105	19			
		LEAN TO FAT CLAY: Brown, trace gray, trace sand and fine gravel, occasional cobbles and possible boulders, very stiff to hard (Glacial Drift)	SH 2	25		3500	1650	111	22			
10			SH 3	11		4000		119	15			
			SPT 4	10	20-50/5"	1000			18			
			SPT 5	8	31-50/5"	9000			10			
20			SPT 6	6	33-50/5"	9000			12			
			SPT 7	18	8-15-27 (42)	9000			17			
28.0												
30.0		LEAN TO FAT CLAY: Dark gray, with gravel, trace sand, occasional cobbles and boulders, very stiff to hard (Glacial Drift)	SPT 8	16	10-13-20 (33)	8500			19			
		Bottom of borehole at 30.0 feet.										

CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses

PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri

DATE STARTED 6/30/14 **COMPLETED** 6/30/14 **GROUND ELEVATION** 755 ft **HOLE SIZE** 6"

DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**

DRILLING METHOD 6" HSA **AT TIME OF DRILLING** 7.00 ft / Elev 748.00 ft

LOGGED BY Rathe **CHECKED BY** Lidholm **AT END OF DRILLING** ---

NOTES 1hrs AFTER DRILLING 7.00 ft / Elev 748.00 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.0		TOPSOIL: with gravel (12 inches) 754.0										
3.5		FILL: Gravel and cobbles, 1-inch minus crushed limestone aggregate 751.5	⊗ SPT 1	8	22-18-4 (22)	9000			8			
		FILL: Lean to Fat Clay, brown, trace root hairs, trace gravel and fine gravel, stiff	⊗ SPT 2	5	3-2-5 (7)	3000			14			
10			⊗ SPT 3	1	4-2-1 (3)	9000			16			
		--: black and brown, trace sand, medium	⊗ SPT 4	13	3-5-3 (8)	1500			25	38	15	23
17.0		LEAN TO FAT CLAY: Dark gray and orangish brown, trace fine gravel, trace to with gravel, very stiff (Glacial Drift) 738.0	⊗ SPT 5	14	3-6-6 (12)	5000			26			
25.0		--: light brown, trace fine sand, hard 730.0	⊗ SPT 6	15	8-16-18 (34)	9000			20			

Bottom of borehole at 25.0 feet.

CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses

PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri

DATE STARTED 6/30/14 **COMPLETED** 6/30/14 **GROUND ELEVATION** 751 ft **HOLE SIZE** 6"

DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**

DRILLING METHOD 6" HSA ▽ AT TIME OF DRILLING 5.00 ft / Elev 746.00 ft

LOGGED BY Rathe **CHECKED BY** Lidholm **AT END OF DRILLING** ---

NOTES --- **AFTER DRILLING** ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.0		FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate										
4.0		FILL: Cinders, black, loose										
		▽ Fill: Dark gray, trace light brown, trace fine gravel, trace gravel, soft to medium										
10			⊗ SPT 1	14	7-3-3 (6)	4000			24			
			⊗ SPT 2	10	2-1-2 (3)	500			12			
			⊗ SPT 3	13	1-3-7 (10)	1000			29	42	15	27
			⊗ SPT 4	18	2-2-3 (5)	1000			27			
20			⊗ SPT 5	10	7-12-13 (25)	500			35			
25.0		--: with white, trace rust stains, hard	⊗ SPT 6	18	5-11-14 (25)	9000			30			
		Bottom of borehole at 25.0 feet.										

CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses
PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri
DATE STARTED 6/30/14 **COMPLETED** 6/30/14 **GROUND ELEVATION** 753 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**
DRILLING METHOD 6" HSA ▽ AT TIME OF DRILLING 7.00 ft / Elev 746.00 ft
LOGGED BY Rathe **CHECKED BY** Lidholm **AT END OF DRILLING** ---
NOTES --- **AFTER DRILLING** --- Borehole backfilled upon completion

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.0		FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate	752.0									
		LEAN TO FAT CLAY: Light brown, trace gray, trace reddish orange, trace black, trace gravel, stiff (Glacial Drift)	ST 1	14		3000	1190	107	19			
		▽	ST 2	11		2500		101	24			
10		--: dark gray, trace light brown, trace root hairs, very stiff	ST 3	18		5000			26			
		--: gray and orangish brown, trace fine sand	ST 4	22		5500		105	22			
19.6		--: with gravel, reddish brown	733.4						12			
		Refusal at 19.6 feet. Bottom of borehole at 19.6 feet.	SPT 5	9	20-46-50/1"	9000						

CLIENT City of Columbia **PROJECT NAME** Power Plant Dam Stability Analyses
PROJECT NUMBER G13043 **PROJECT LOCATION** Columbia, Missouri
DATE STARTED 6/30/14 **COMPLETED** 6/30/14 **GROUND ELEVATION** 752 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR IPES **GROUND WATER LEVELS:**
DRILLING METHOD 6" HSA **AT TIME OF DRILLING** 3.50 ft / Elev 748.50 ft
LOGGED BY Rathe **CHECKED BY** Lidholm **AT END OF DRILLING** ---
NOTES 0.25hrs AFTER DRILLING 3.50 ft / Elev 748.50 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		
										LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0												
1.0		FILL: Gravel, parking lot surface, 1-inch minus crushed limestone aggregate, with cinders	ST 1	17		3000			21			
		LEAN TO FAT CLAY: Dark gray, trace light brown, trace fine gravel, stiff (Glacial Drift) --: trace root hairs, with gravel	ST 2	11		3500			19			
10		--: with gravel and cobbles from 11.0' - to 13.0'	SPT 3	8	4-5-2 (7)				24			
			SPT 4	18	1-1-2 (3)				34			
20		--: becomes brown, with gravel and sand	SPT 5	12	6-12-15 (27)	3000			22			
25.0		Bottom of borehole at 25.0 feet.	SPT 6	5	7-9-11 (20)	8500			17			

SAMPLE LENGTH REPORT - LAT-LONG TEMPLATE.GDT - 7/25/14 15:34 - C:\SERVER FILES\GEOTECH GENERAL\PROJECTS\G13043 - MORES LAKE DAM STABILITY ANALYSES\G13043.GPJ

BORING LOG LEGEND AND NOMENCLATURE

Sample Type

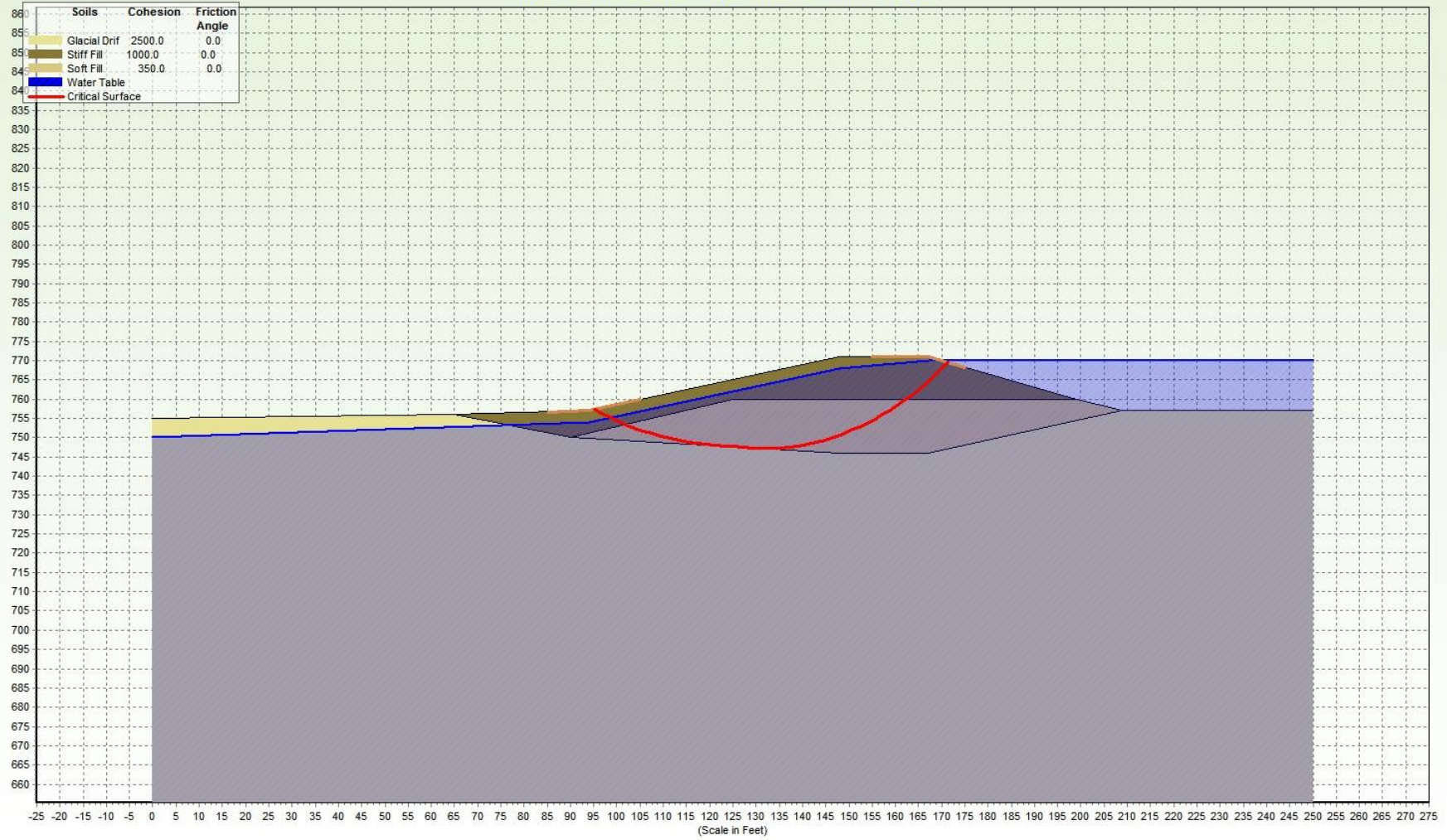
AU	Auger Sample, disturbed, obtained from auger cuttings
NR	No recovery or lost sample
RC	Rock core, diamond core bit, nominal 2-inch diameter rock sample (ASTM D 2113)
ST	Thin walled (Shelby) tube sample, relatively undisturbed (ASTM D 1587)
SPT	Split-spoon sample, disturbed (ASTM D 1586)
VA	Shear vane (ASTM D 2753)

Grain Size Terminology		Relative Proportions of Sand and Gravel	
Boulders	Larger than 12-inches	Trace	Less than 15 %, by dry weight
Cobbles	3-inches to 12-inches	With	More than 15% but less than 30%, by dry weight
Gravel	retained on #4 sieve to 3-inches	Modifier	More than 30%, by dry weight
Sand	retained on #200 sieve but passes #4 sieve		
Silt or Clay	passes #200 sieve		

Relative Density of Fine Grained Soil		Consistency of Fine Grained Soil		
Descriptive Term	SPT N-Value Blows/Foot	Descriptive Term	SPT N-Value Blows/Foot	Unconfined Compressive Strength, psf
Very Loose	0 - 4	Very Soft	0 - 2	0 - 500
Loose	4 - 10	Soft	2 - 4	500 - 1,000
Medium Dense	10 - 30	Medium	4 - 8	1,000 - 2,000
Dense	30 - 50	Stiff	8 - 15	2,000 - 4,000
Very Dense	50+	Very Stiff	15 - 30	4,000 - 8,000
		Hard	30+	8,000+

USCS SOIL CLASSIFICATION SYSTEM						
Major divisions			Group Symbol		Group Name	
Coarse grained soils more than 50% retained on #200 sieve	gravel › 50% of coarse fraction retained on No. 4 (4.75 mm) sieve	clean gravel ‹5% smaller than #200 Sieve	GW		well-graded gravel, fine to coarse gravel	
			GP		poorly graded gravel	
		gravel with ›12% fines	GM		silty gravel	
			GC		clayey gravel	
	sand ≥ 50% of coarse fraction passes No.4 sieve	clean sand	SW		well-graded sand, fine to coarse sand	
			SP		poorly graded sand	
		sand with ›12% fines	SM		silty sand	
			SC		clayey sand	
Fine grained soils more than 50% passes #200 sieve	silt and clay liquid limit ‹ 50	inorganic	ML		silt	
			CL		clay	
		organic	OL		organic silt, organic clay	
	silt and clay liquid limit ≥ 50	inorganic	MH		silt of high plasticity, elastic silt	
			CH		clay of high plasticity, fat clay	
		organic	OH		organic clay, organic silt	
Highly organic soils			PT		peat	

Problem: B-1 & B-2 A Analysis - FS Min- Janbu = 2.278



SLOPE STABILITY

End of Construction
MORES LAKE DAM
Columbia, MISSOURI

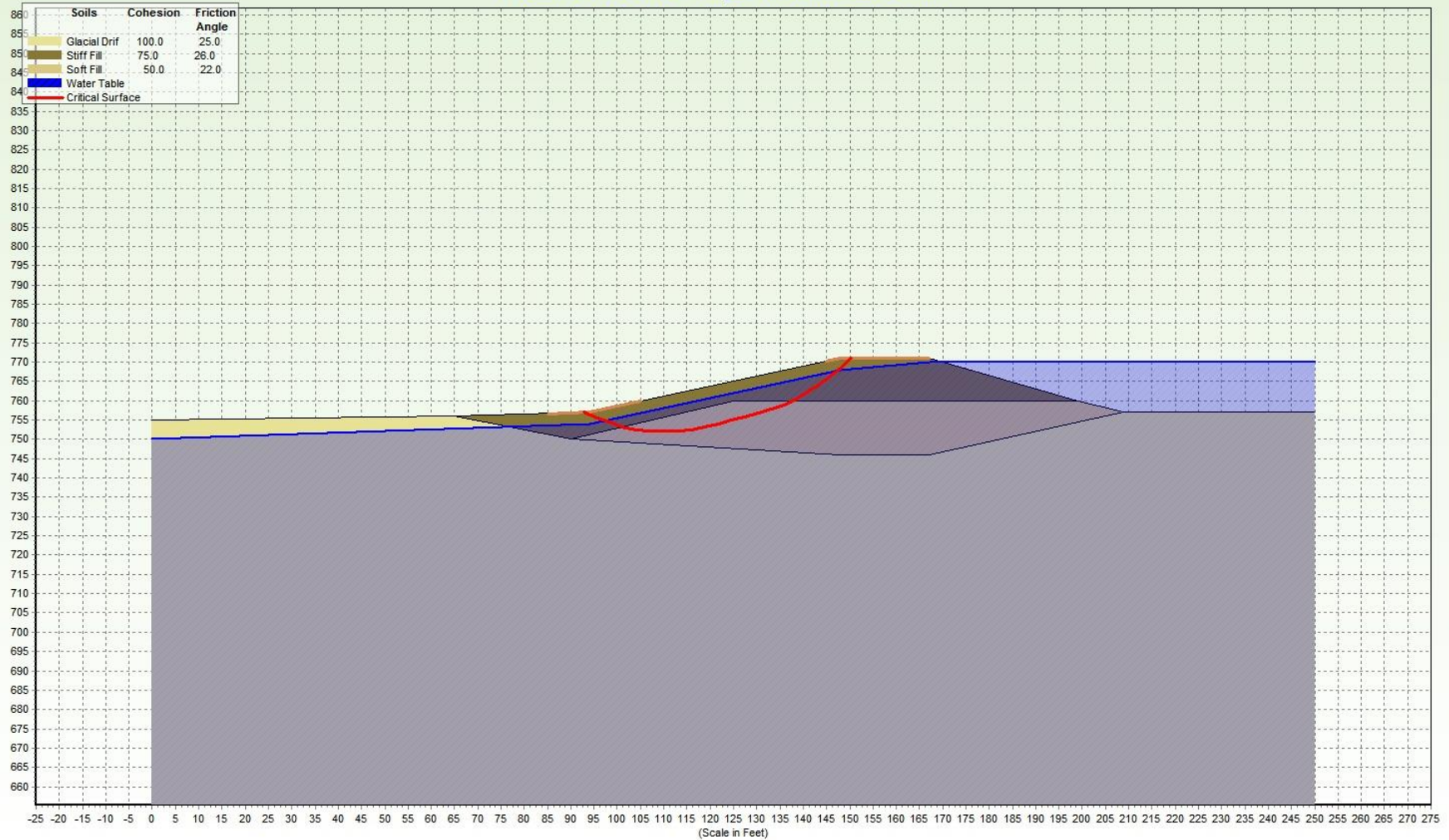
PROJECT NO.: G13043

Prepared By:

CROCKETT
GEOTECHNICAL - TESTING LAB

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Problem: B-1 & B-2 BC Analysis - FS Min- Janbu = 2.155



SLOPE STABILITY

Long Term - Maximum Surcharge Pool
MORES LAKE DAM
 Columbia, MISSOURI

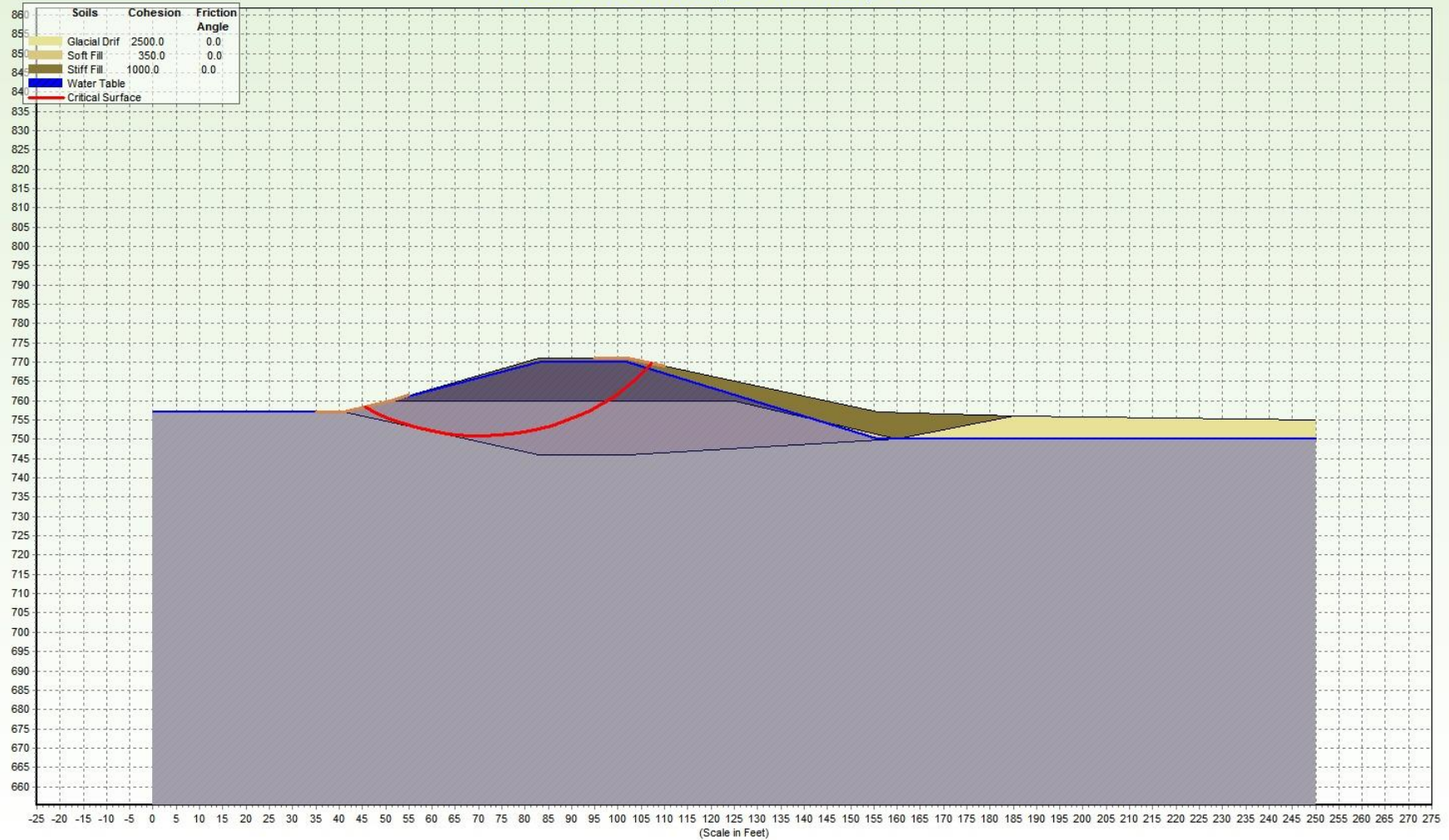
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Problem: B-1 & B-2 D Analysis - FS Min- Bishop = 2.261



SLOPE STABILITY

Rapid Drawdown
MORES LAKE DAM
Columbia, MISSOURI

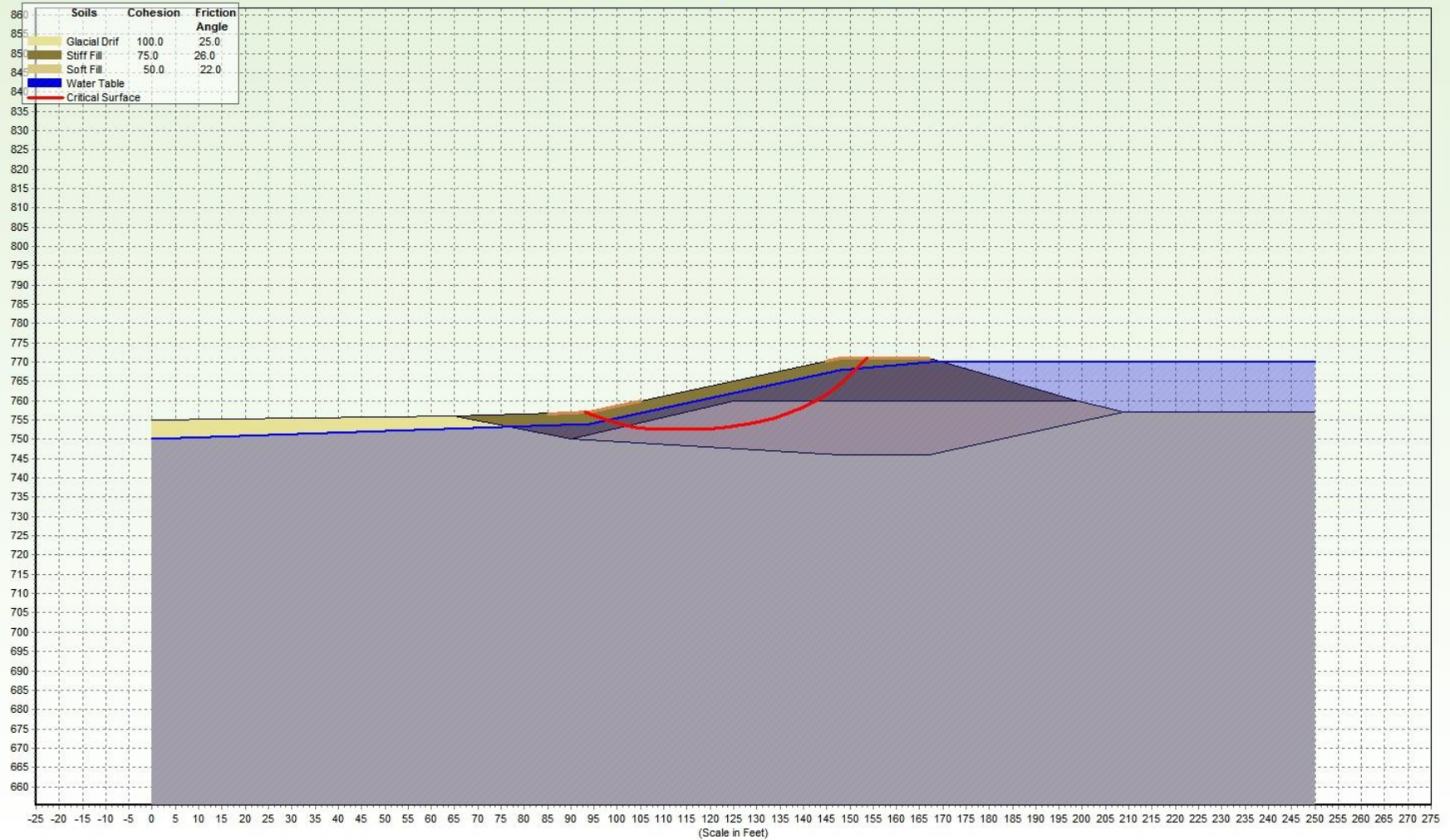
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Problem: B-1 & B-2 E Analysis - FS Min- Janbu = 1.091



SLOPE STABILITY

Seismic

MORES LAKE DAM
Columbia, MISSOURI

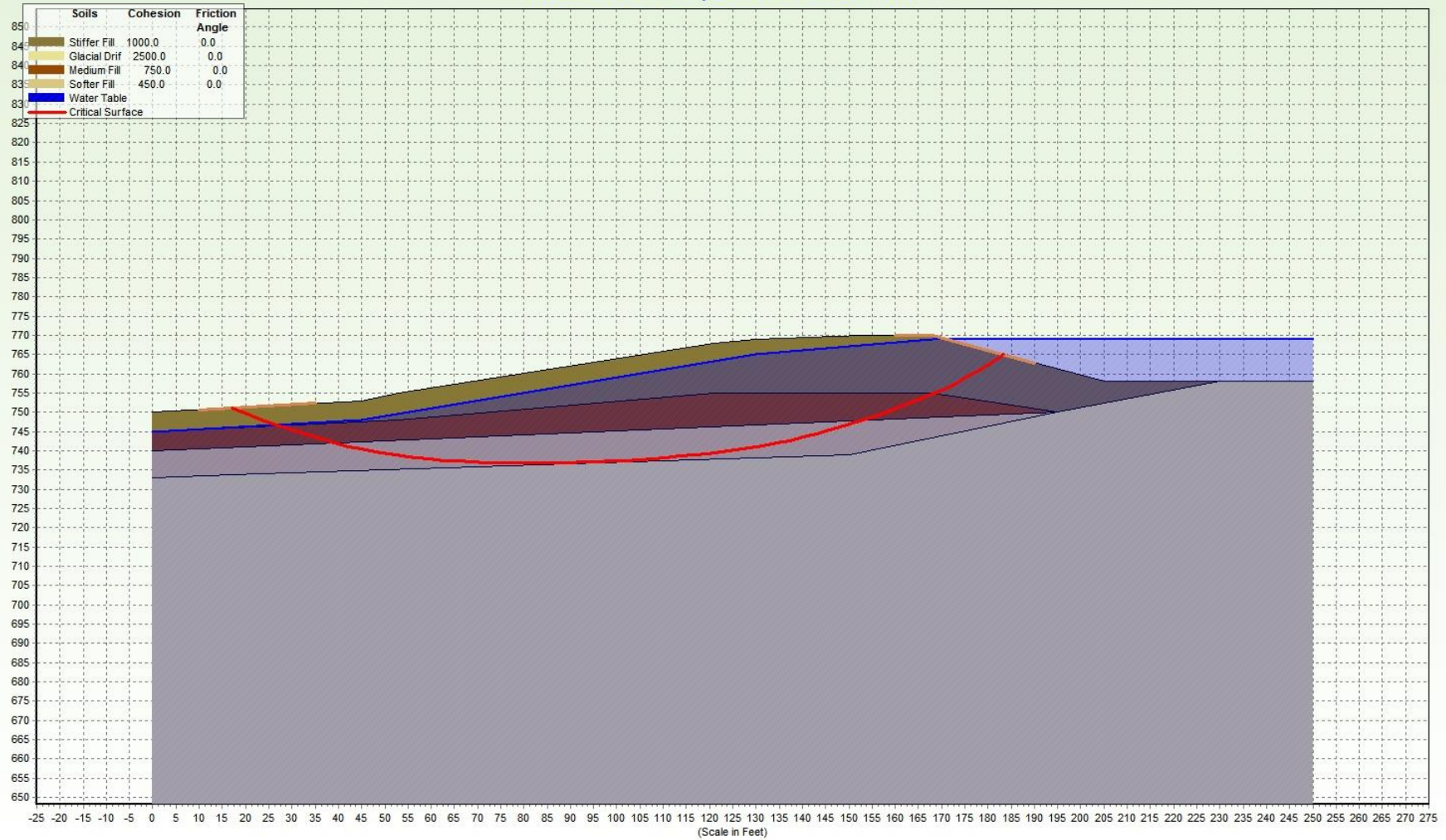
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Problem: B-3/B-4 A Analysis - FS Min- Janbu = 1.016



PROJECT NO.: G13043

SLOPE STABILITY

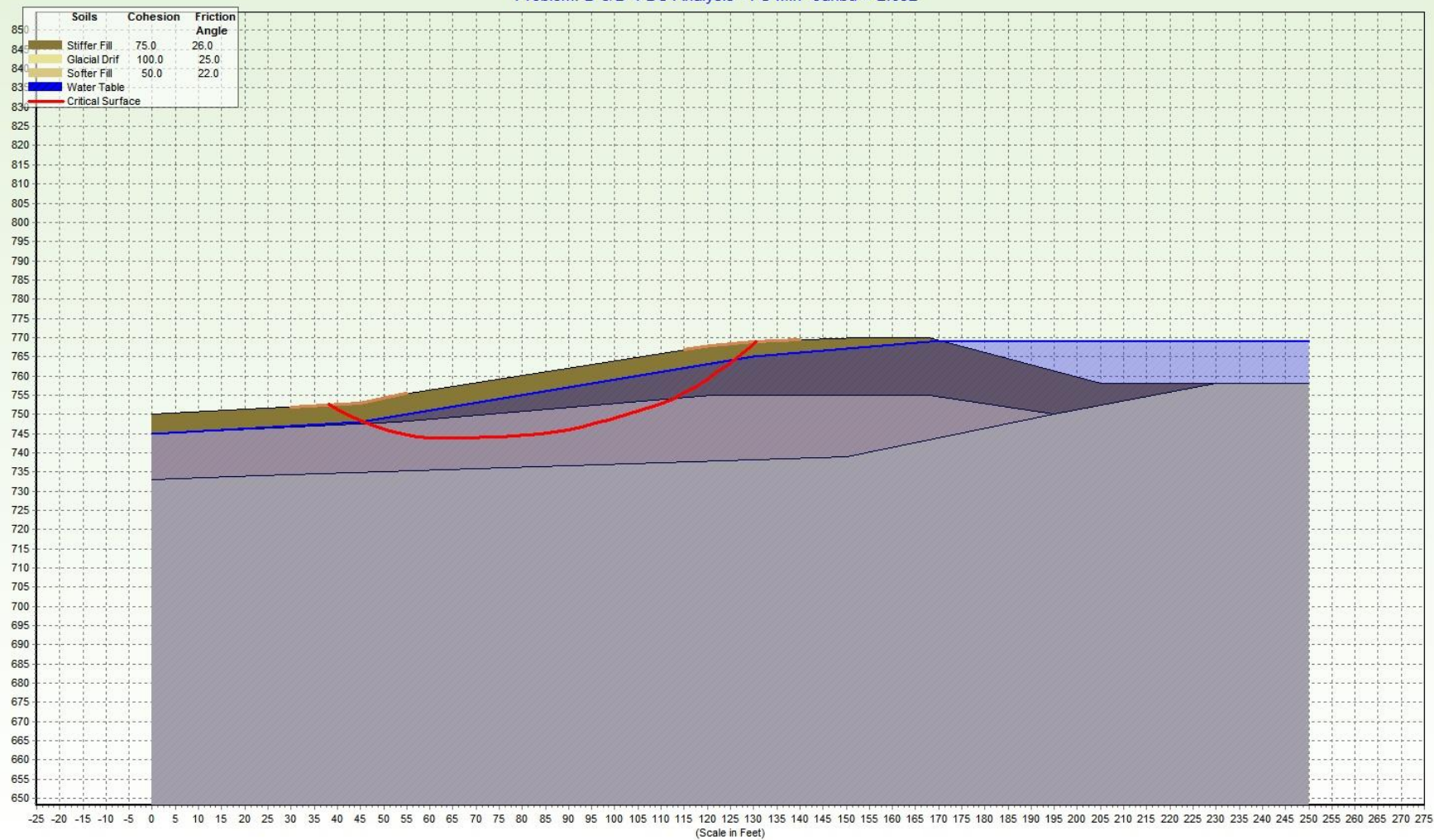
End of Construction
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Problem: B-3/B-4 BC Analysis - FS Min- Janbu = 2.692



SLOPE STABILITY

Long Term - Maximum Surcharge Pool

MORES LAKE DAM
Columbia, MISSOURI

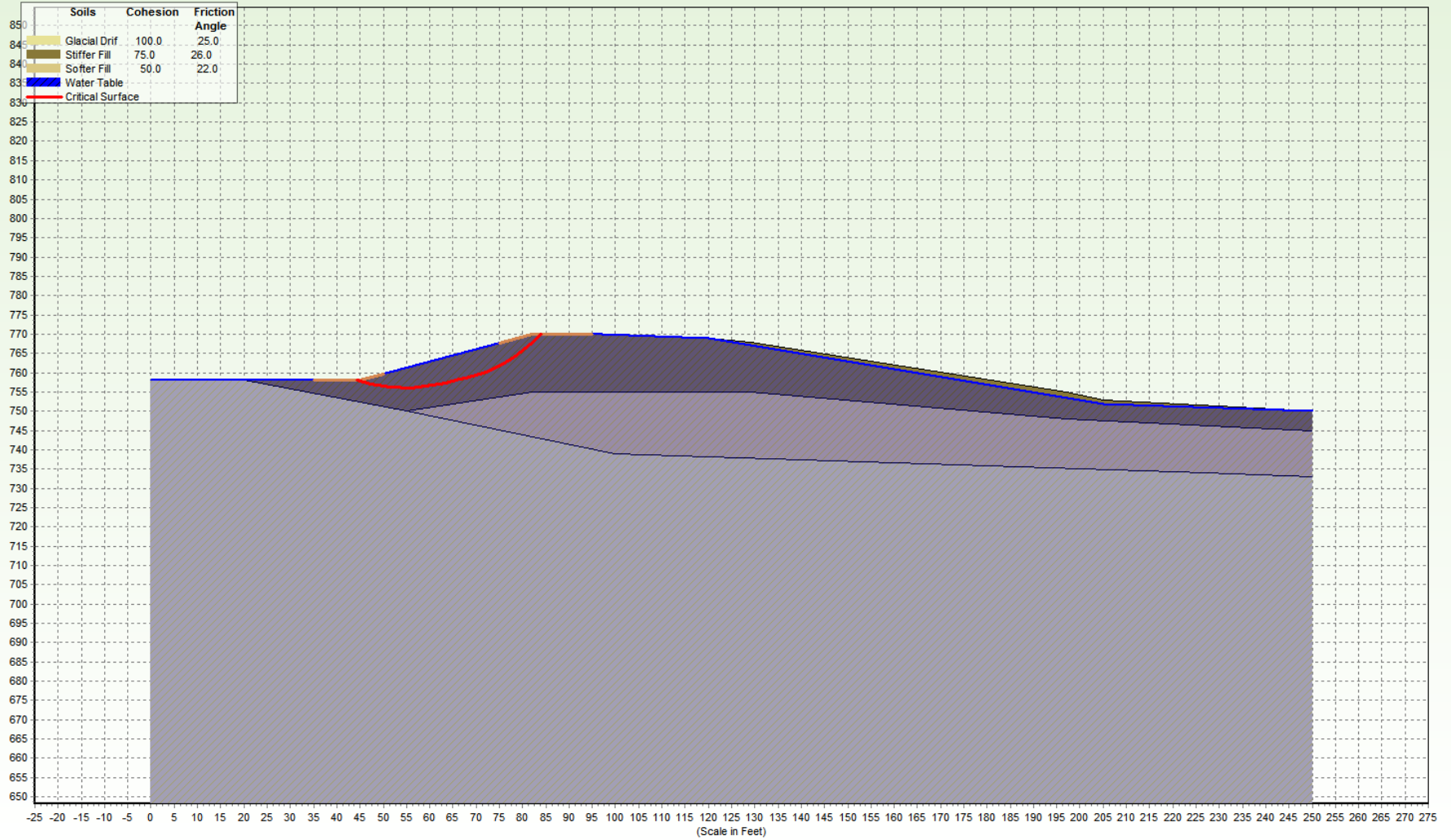
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Problem: B-3/B-4 D Analysis - FS Min- Janbu = 2.293



SLOPE STABILITY

Rapid Drawdown
MORES LAKE DAM
Columbia, MISSOURI

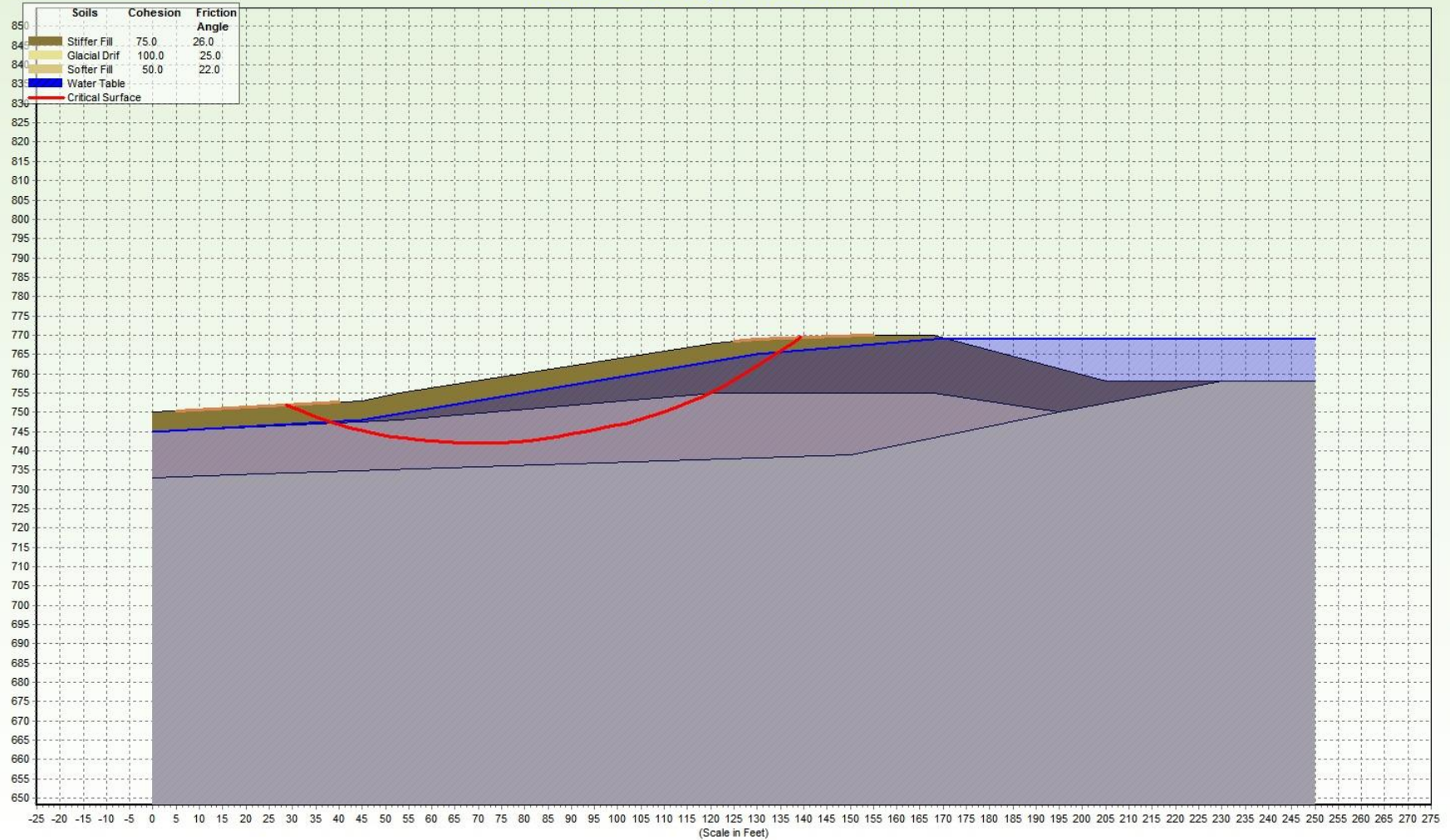
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Problem: B-3/B-4 E Analysis - FS Min- Janbu = 1.16



SLOPE STABILITY

Seismic

MORES LAKE DAM
Columbia, MISSOURI

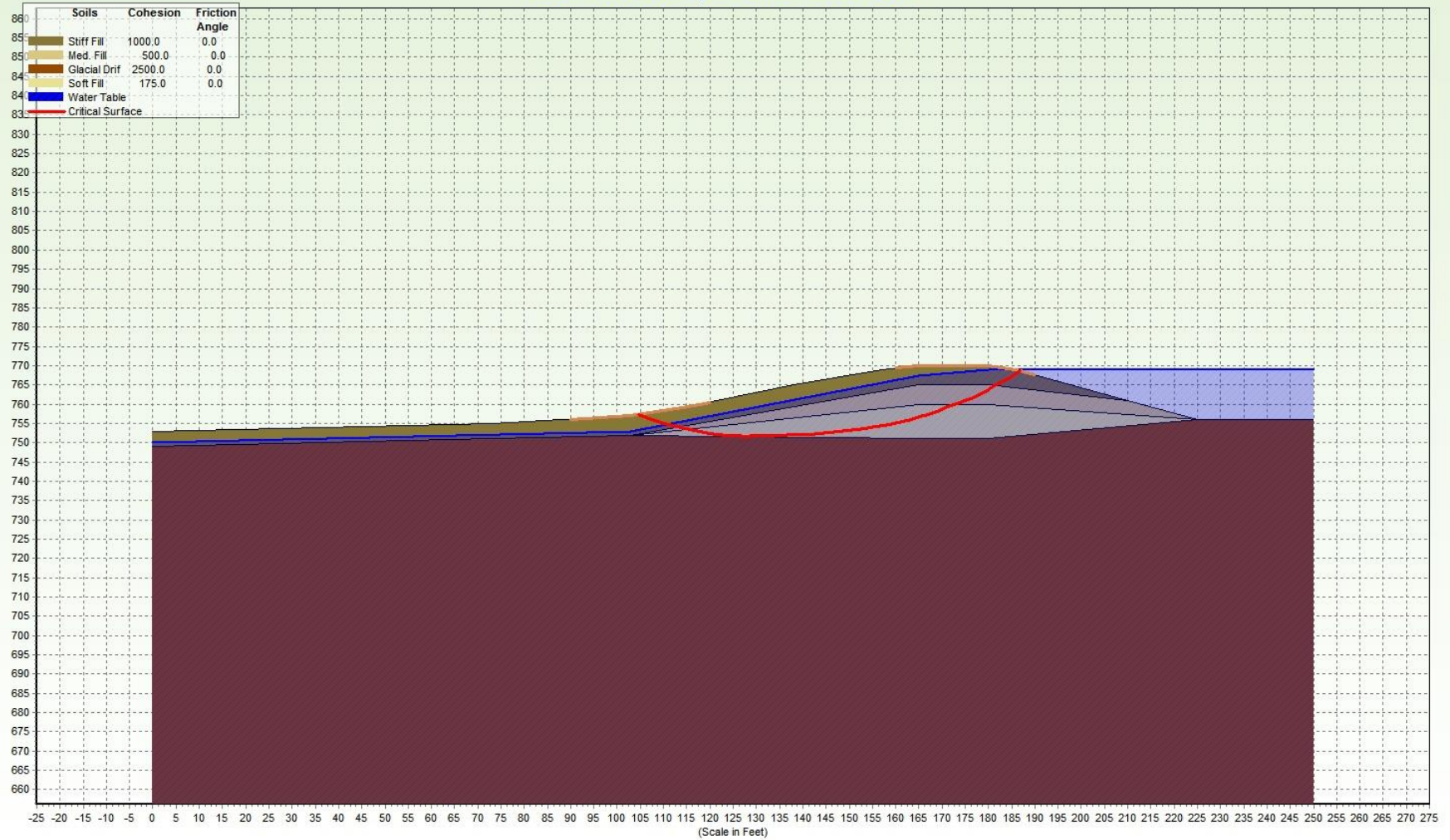
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Problem: B5/B-6 A Analysis - FS Min- Janbu = 2.258



SLOPE STABILITY

End of Construction
MORES LAKE DAM
Columbia, MISSOURI

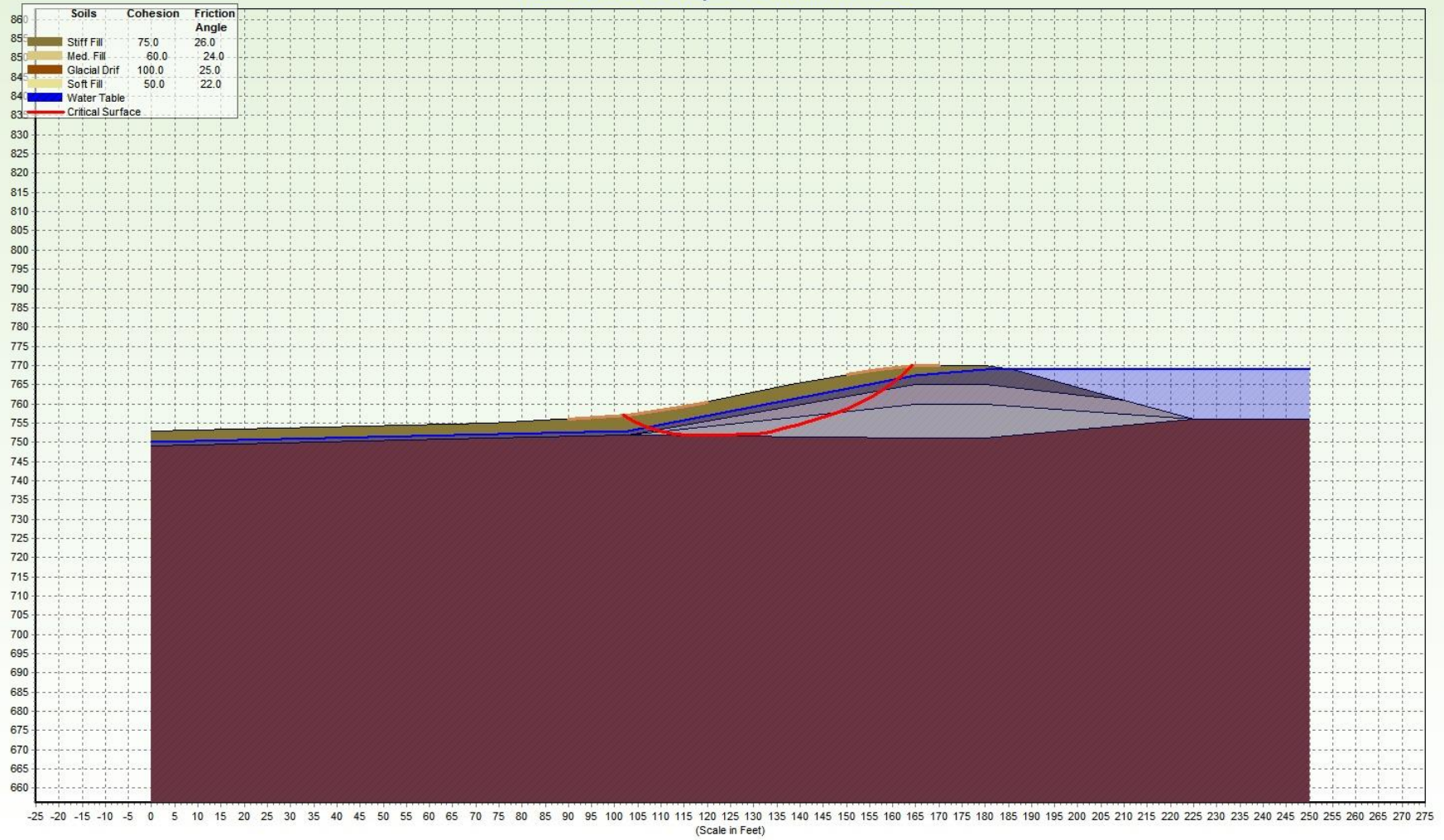
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Problem: B5/B-6 BC Analysis - FS Min- Janbu = 2.409



PROJECT NO.: G13043

SLOPE STABILITY

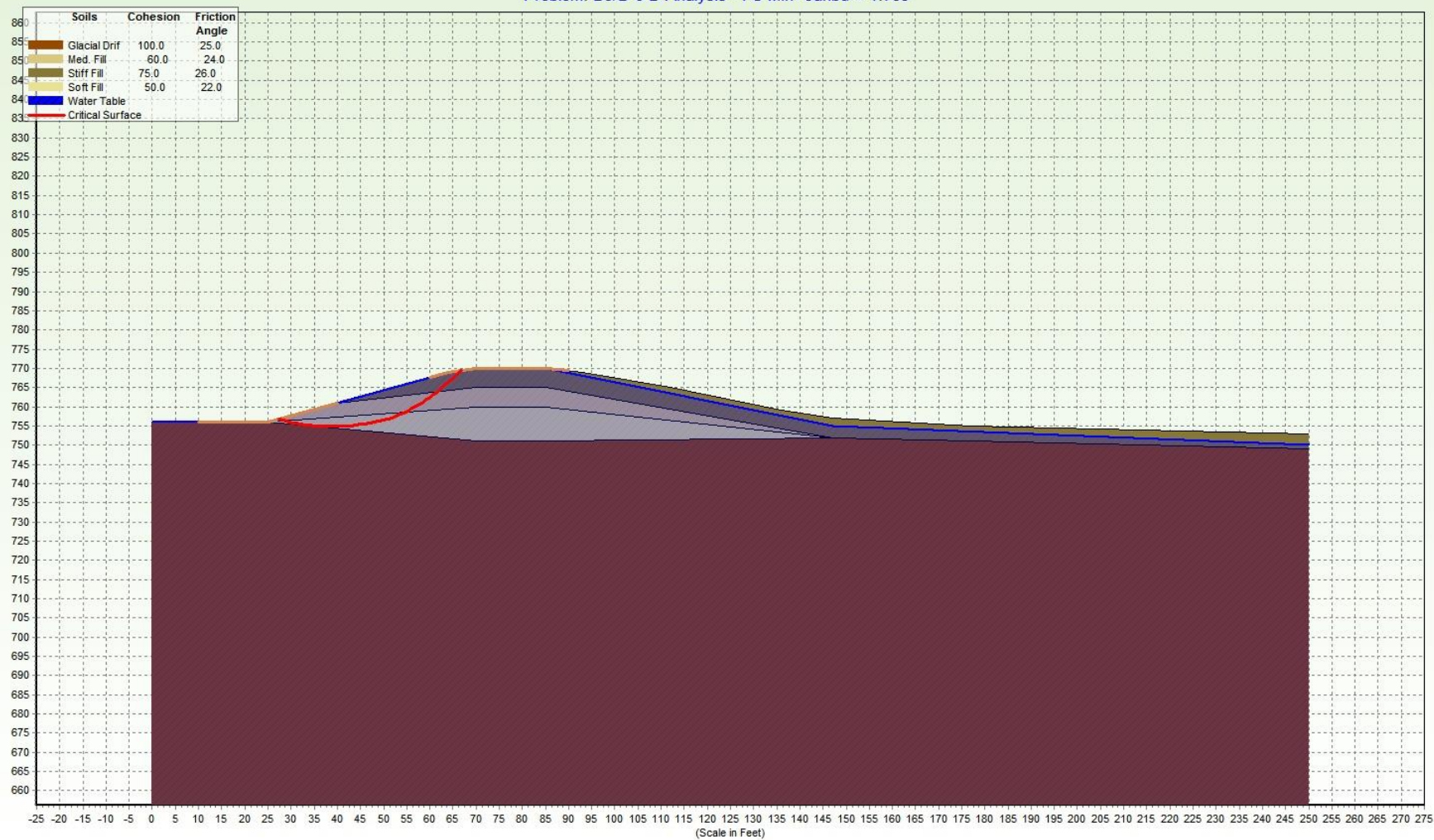
Long Term - Maximum Surcharge Pool
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Problem: B5/B-6 D Analysis - FS Min- Janbu = 1.759



SLOPE STABILITY

Rapid Drawdown
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Columbia, MISSOURI

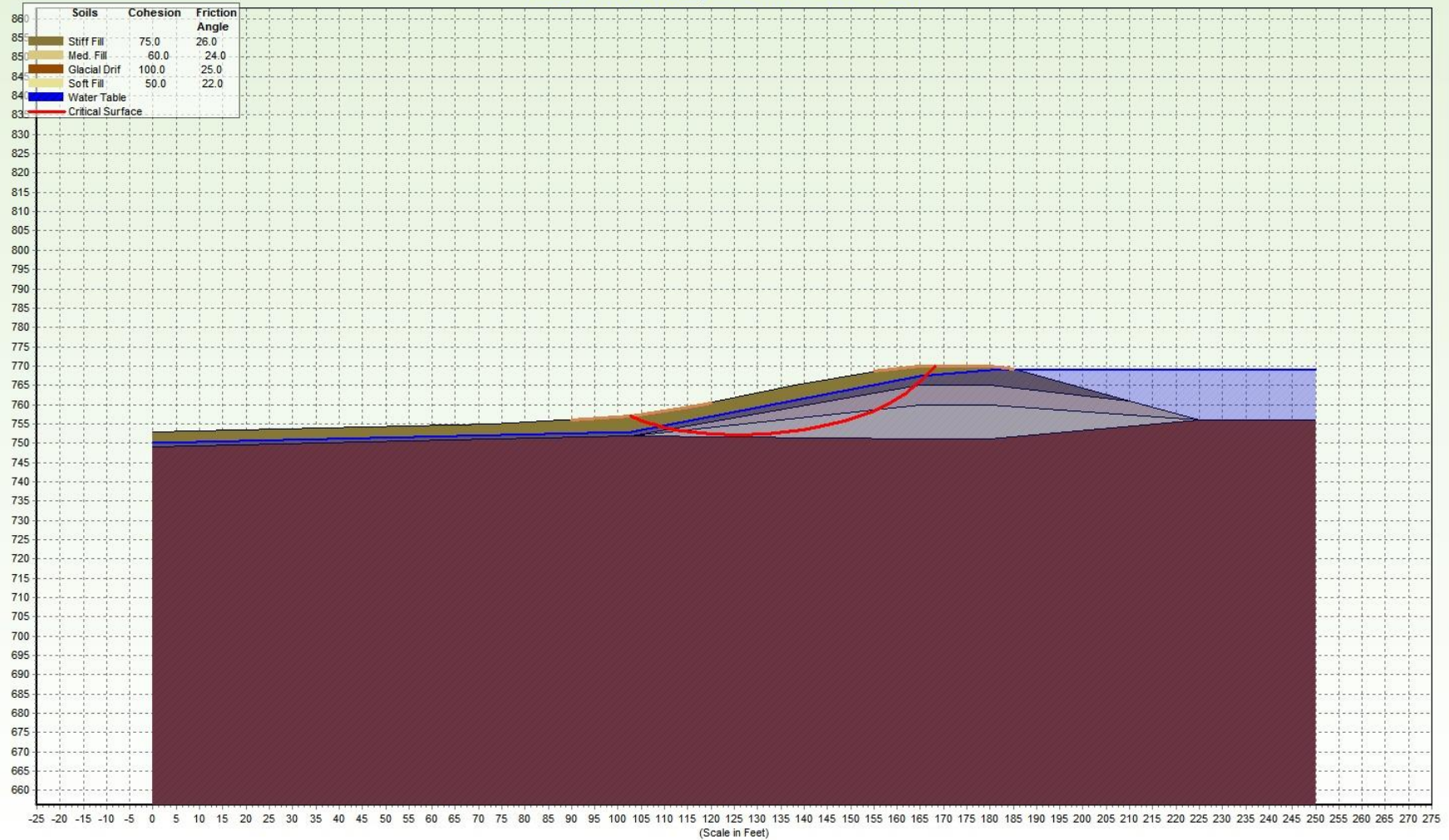
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Problem: B5/B-6 E Analysis - FS Min- Janbu = 1.141



SLOPE STABILITY

Seismic

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